THE UNIVERSITY OF ALBERTA

THE COMPARATIVE EFFECTS OF PRESENTATION MODE ON SUCCESS IN ARITHMETIC PROBLEM SOLVING

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Comparative Effects of Presentation Mode on Success in Arithmetic Problem Solving" submitted by Alvin L. Anderson in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

This study investigated the relationship of mode of presentation to student performance in arithmetic problem solving. Other variables studied were reading ability, arithmetic ability and type of school.

The population used in this study consisted of 234 grade six students in the six Alberta schools, three of which were Individually Prescribed Instruction (IPI) schools, and three were Control schools. All grade six students in these schools were randomly assigned to one of four presentation modes of a problem solving test. These test modes consisted of the R-mode, based on the written word, an LR-mode which included a taped accompaniment of the printed test, plus the same R-mode; the VR-mode that consisted of visuals to accompany the R-mode; and the fourth alternate, the RLV-mode combining the reading, listening and visual aspects of communication.

Students were also administered the reading section of The Metropolitan Achievement Test and from the results of this test grouped into high and low ability readers. A similar high and low dichotomy was obtained for all subjects on the basis of arithmetic ability as measured by the arithmetic section of The Canadian Test of Basic Skills.

Both the one-way analysis of variance and two-way

analysis of covariance were the statistical techniques used in the analysis of the resulting data.

The analysis revealed that within the total sample studied, there were no significant differences between the four modes of presentation. There were significant differences between high and low ability students in arithmetic and reading with respect to the four different modes of presentation. There were no significant differences between the two types of schools. No significant interactions between mode of presentation and each of the variables of arithmetic ability, reading ability and type of school were found.

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INTRODUCTION TO THE STUDY

GENERAL INTRODUCTION

Whatever the classroom organization within a school, the teacher or teaching team is required to make repeated instructional decisions. For example, how can the content best be presented for a desired learning situation? Or, how could instruction be differentiated in order to accommodate various individual and multiple groupings? There are questions which are related to the pacing of subject matter, and with considerations of the individual's abilities, interests, and needs. These are issues which should be the concern of all those who have a part in dertermining classroom practice.

Team teaching, non-graded classrooms, programed learning, and student grouping, have been organizational techniques designed to administratively accommodate the many differences among individual learners. Currently, in order to approach new solutions to questions raised above, many educators are engaged in active research on individualized instruction and learning. The Science Research Associates and Research for Better Schools group are two organizations that are doing work in this area. There are other subject

programs such as The Individualized Mathematics Curriculum Project (IMCP) that pursue similar lines of research.

Individually Prescribed Instruction (IPI), being field-tested by Research for Better School, typifies active research into individualized learning. Hypothetically, IPI consists of "planning and conducting, with each student, a program of studies that is tailored to his needs and to his characteristics as a learner" (Human Resources Research Council Prospectus, 1969).

The program, currently under study by the Human Resources Research Council of Alberta, in three Alberta schools, more specifically, is a project exploring such areas as rate of learning, amount of practice, and to some extent, preference for mode of presentation.

This study will concentrate on mode of presentation in mathematical problem solving.

BACKGROUND AND JUSTIFICATION OF THE PROBLEM

"Reading in the language of arithmetic demands mastery of both verbal and mathematical symbols. The language in the mathematics field is concise, the reading is precise, particular and critical" (Taschow, 1969, p. 1).

There is also evidence that the predominant arithmetic problem solving mode is the printed word, and that many of our readers, both student and adult, demonstrate less than satisfactory performances in reading. This has spelled failure to many students. A closer look at what reading is may

better convince us of this fact.

Harris (1962) says that reading is a communication between someone who has something to express and someone who receives the message. He sees reading as an "active process that requires the focusing of the eyes on printed symbols in terms of past recollections of the word" (p. 10). Reading, he says, "is a process in which meaning builds up as the concepts aroused by the printed word become organized into larger and more comprehensive ideas" (p. 10). This meaning should illicit a reaction on the part of the learner, according to Harris. "Reading is a way of learning, changing, and developing . . . it can enrich and enable, it can delude and debase" (p. 13).

What is also important for successful reading is the experiential background of the child. Jenkinson (1960) stressed the importance of bringing meaning to the printed page. She says that "constructing meaning is a vital prerequisite of all reading" and she points out that reading "is a form of thinking, problem-solving or reasoning which involves analyzing and discriminating, judging, evaluating and synthesizing" (p. 1). Trump (1947) supports this view when he states that "a child can read with comprehension to the extent that he brings to the activity a suitable background experience" (p. 56). This background, to Trump, involves two essential parts, that part which relates to the mechanics of reading and language, and that part which relates to context.

The child then, who lacks a suitable background of related experience, most likely will have reading difficulties, and consequently, in solving verbal arithmetic problems.

To the experiential requirement in reading, Trump (1947) also adds the need for a "consistent interest, desire and purpose" (p. 56). Student attitude toward a subject does affect performance in that subject. Although research has shown that mathematical activities are generally enjoyed by students, Dutton (1956), for example, reported that major reasons for pupils dislike of mathematics include lack of understanding, high level difficulty, poor achievement, and lack of interest in certain aspects of mathematics. Harris (1962) says that "parents whose own educational experiences were less than satisfactory, and whose work demands little or no education, tend to place little importance on education in general and reading in particular" (p. 7).

Relating reading and mathematics, Smith (1965) has made the statement that "reading is a complex activity, especially when compounded with mathematical word problems" (p. 198). Mathematics text, she says, is unique from other textual material in that "it is complicated by having numerical symbols woven into the sentences, along with the word symbols" (p. 198).

Considering the problem more closely, Johnson (1966) says that:

> A pupil in mathematics looks upon a situation as a problem provided that he feels impelled toward action for some reason or another, that he has clearly in mind what the goal is, and that he is puzzled but not

frustrated about what action to take (p. 8).

Cross and McDonald (1958) add a complexing note to problem solving, when they say the process involves three necessary but difficult functions: "(1) an orientation function, (2) an elaborative and analytic function, and (3) a critical function" (p. 260).

Not all students possess the level of thinking required for success in much of the school's problem-solving curriculum. As a result, many could become frustrated to the point of not really becoming involved in the problem. Cronbach (1948) gave support to an earlier conjecture, that a problem may not be communicated to the solver for a variety of reasons. He emphasized that "difficulty may ensue because reading skills of a high order are required to make sense of complex sentences found in the statement of problems" (p. 5).

In summary then, the complexity of both the communication and problem solving processes cause students a good deal of misery. It is questions related to these complexities that this study wishes to pursue. Specifically, could students become more successful in arithmetic problem solving, if individual instructional styles were taken into account? Could mode of presentation of problems be a worthwhile consideration for instructional programs which are individualized in design?

STATEMENT OF THE PROBLEM

The classroom teacher, one of whose tasks is the

efficient presentation of subject content, has several avenues of communication available. Two of these avenues are the audio and the visual.

In presenting arithmetic problems, several variations of these two forms can be utilized. For example, a student can have the problem read to him by the teacher, or via the tape recorder. The problems can also be presented in a form where the printed word is supplemented with visual illustrations. In addition, combinations of the verbal (reading), audio, and visual could form alternate presentation modes for problem solving content.

For example, the following presentation mode combinations are possible:

(1) Reading Mode (R)

(2) Listening - Reading Mode (LR)

(3) Visual - Reading Mode (VR)

(4) Reading - Listening - Visual Mode (RLV)

As to how the above four modes may be utilized in presenting mathematics content to students the following may be considered exemplar.

The reading mode (R) is heavily used in such instances as choosing, using and evaluating arithmetic texts and resource materials; following directions; interpreting and translating mathematical words and symbols; and in solving verbal problems. Concept areas, such as geometry, number representations, graphs and "arithmetic in nature," are those which perhaps lend themselves more toward visual

presentation modes.

Expanded production and use of educational film and tape combined with the perfected electronics media (e.g. television) have resulted in vast opportunities for multi-sensory arithmetic experiences for students. Perhaps all areas of mathematics can be advantageously presented through those media which involve students in various combined forms of listening (L), reading (R), and visualizing (V). Today, mathematics games and laboratory experiences are providing exciting multimode avenues for communicating concepts in such areas as geometry, tesselations, design, number and number systems, measurement, the operations, estimating and money. Perhaps the results of much research will underscore the significance of any move toward multi-sensory modes of presenting mathematics to children.

With this thought, the purposes of this study are:

(1) To determine the relationship of modes of presentation to student performance in arithmetic problem-solving, when reading achievement and arithmetic achievement are controlled both together and separately.

(2) To determine the effects of modes of presentation on student performance in arithmetic problem solving for students in the IPI and control schools, when controlling, both together and separately for arithmetic and reading achievement.

DEFINITION OF TERMS

Verbal Problem Solving - refers to the quantitative situation stated in words (rather than mathematical symbols only) so that the essential elements and the aritmetic process necessary for its solution must be determined by the problem solver.

R-test - a ten question arithmetic problem solving test stated in words rather than symbols only (Appendix 1).

LR-test - a verbal problem solving test (R-test) plus a taped verbatim accompaniment.

VR-test - a verbal problem solving test (R-test) with equivalent content accompanied in visual form.

RLV-test - a verbal problem solving test (R-test) plus the taped (listening) and the pictured (visual) problem solving test equivalents.

HA - a group of students who scored above a set criterion measure in reading and/or arithmetic.

LA - a group of students who scored below a set criterion measure in reading and/or arithmetic. (Note: Criteria for HA and LA designations are outlined in Chapter 3).

IPI Schools - the schools and students who are involved in the experiments in Individually Prescribed Instruction under the direction of the Human Resources Research Council of Alberta. They are Forest Heights in Edmonton, St. Vincent De Paul in Calgary and Millarville in the Foothills School Division.

Control Schools - those schools selected by the

Alberta Human Resources Research Council to serve as controls for the IPI schools. They are Princeton in Edmonton, St. Leo in Calgary and Red Deer Lake in the Foothills School Division.

HYPOTHESES TO BE TESTED

(1) On the criteria of problem solving, there are no significant differences among the scores of groups who were presented with different modes.

(2) Controlling for reading ability there is no significant interaction between modes of presentation and arithmetic ability, relative to the criteria of problem solving.

(3) Controlling for reading ability there are no significant differences between high and low arithmetic ability groups on the criteria of problem solving.

(4) Controlling for arithmetic ability there is no significant interaction between modes of presentation and reading ability, relative to the criteria of problem solving.

(5) Controlling for arithmetic ability there are no significant differences between the high and low reading ability groups on the criteria of problem solving.

(6) Controlling for reading and arithmetic ability there is no significant interaction between types of schools (IPI - control) and modes of presentation relative to the criteria of problem solving

(7) Controlling for reading and arithmetic ability there are no significant differences between IPI and control schools on the criteria of problem solving.

(8) Controlling for reading ability there are no significant differences between IPI and control schools on the criteria of problem solving.

(9) Controlling for arithmetic ability there are no significant differences between IPI and control schools on the criteria of problem solving.

LIMITATIONS OF THE STUDY

(1) Personal factors: There was no attempt to determine the influence of socio-economic status, motivational level, or exact age.

(2) Motivational factors: There was no deliberate attempt to extrinsically motivate the subjects. A short explanation of the operation of the car odometer and the significance of yard markings on the football field may, however, have had some motivational effect.

(3) Instrument factor: Since the test designed by the researcher was not validated, perhaps this could be regarded as a limitation of the study.

(4) Geographic area: The general location of the population schools was not considered in this study. Choices of IPI and control schools, made by the Human Resources Research Council of Alberta were accepted for this study.

THE EXPERIMENTAL SETTING

The population for this study consisted of all grade six students (243) in the IPI and Control Schools currently

being studied by the Human Resources Research Council of Alberta.

Since both the reading and arithmetic abilities of the students taking the four problem solving test modes were to be factors in the study, appropriate tests were administered to all subjects. The reading section of The Metropolitan Achievement Test and the arithmetic concepts and problem solving sections of The Canadian Test of Basic Skills were the specific instruments used to determine student ability in these areas.

OUTLINE OF THE REPORT

In Chapter 1 of this study, the overall and specific problem was introduced. Chapter 2 contains a review of the related literature. Chapter 3 contains a detailed description of each aspect of the experimental design, presentation equipment, materials and method, and the statistical design used to test the hypotheses. The analysis of the research data is contained in Chapter 4. The fifth and final chapter includes a summary of the study, discusses the conclusions and implications of the study and suggests ideas for further research.

Chapter 2

RELATED LITERATURE

PROBLEM SOLVING

Perhaps the one thing that the literature on problem solving has shown is that, although we underscore the significance of the concept, in school and daily life curriculum, we do not fully understand the meaning of the concept. Kilpatrick (1969) writes that "the pre-eminence of problem-solving ability as a goal of mathematics instruction has long been admitted; but like the weather, problem-solving has been more talked about than predicted, controlled or understood" (p. 523). Although this study is not concentrated on problem solving as such, but with the way in which problems are presented, the writer recognizes that there are many factors which can influence the students' success or failure in this phase of the arithmetic program particularly.

Bingham (1958), for example, illustrates the complexity of the problem solving process in her suggested sequence for solving problems.

(1) Identifying the problem and feeling the need to pursue it.

(2) Seeking to clarify the problem and understand its nature, scope and sub-problems.

(3) Collecting data and information related to the problem.

(4) Selecting and organizing the data which apply most pertinently to the crux of the problem.

(5) Determining the various possible solutions in view of the assembled data and knowledge of the problem.

(6) Evaluating the solutions and selecting the best one for the situation.

(7) Putting the solution into action.

(8) Evaluating the problem-solving process employed. (pp. 13, 14)

In the above light it is perhaps understandable why some children have difficulty with problem solving. Besides this complex aspect of process, one finds the subject loaded with intricately related skills. Martin (1963) writes:

> Uncertainty exists concerning the interaction of problem solving ability and other forms of achievement. This is not surprising since the solving of problems is a highly complex process that brings into use all the higher mental processes. Comprehension, inference, association, comparison, abstraction, thinking, reasoning and generalization appear to be involved. (p. 3)

INDIVIDUALS' SKILLS AND PROBLEM SOLVING

As previously mentioned, the written problem seems to be the predominant mode for presenting arithmetic verbal problems. When this is the case, the reading abilities of partaking students are not always considered. Lee and Phillips (1968), for example, compared the reading abilities of one hundred grade six students to the readability of their arithmetic textbooks. From the Gates Reading Survey they obtained a reading score for each student and with all student reading scores, reported a range of from grade 4.0 to grade 10.9. Using the Dale-Chall Formula for Predicting Readability

on their subject's arithmetic text, the authors also obtained individual readability scores. These scores, based on eight text samples, ranged from grades 4.8 to 8.6, with a mean readability of grade 6.6. However, upon closer comparison of the reading achievement of the students, and the readability of the text, they found that 85 percent of the students would have difficulty reading three of the eight text samples, while 30 percent would experience difficulty reading any one of them.

Martin (1963) found that each of the factors of reading comprehension, computation, abstract verbal reasoning and arithmetic concepts were correlated with problem solving ability as measured by the Arithmetic Problem Solving Test section of the Iowa Tests of Basic Skills. On the analysis of the test, given to fourth and eighth graders, she found that the correlation between reading and problem solving ability with computation held constant was higher at both grade levels than the correlation between computational and problem solving ability, with reading held constant.

Tracey (1944) comparing good and poor problem solvers on fifteen reading skills, with mental and chronological age controlled, reported that good achievers were significantly superior to poor achievers in (1) quantitative relationships (2) perception of relationships (3) vocabulary in context and isolation (4) retention of clearly stated details (5) drawing of inferences from context, and (6) reading level.

Curry (1955), discussing the difficulty students have

with arithmetic problem solving, says that one reason for concern is the fact that the reading of problems requires a type of reading that is quite different from other situations. Curry says that in reading problems, "many students give every indication that they are merely repeating words and thus do not attach any meaning to these words" (p. 1). Some children, he says, develop habits of looking for cue words which indicate the process to use in solving a problem, while others simply pull numbers from a problem, then manipulate them in some way to arrive at an answer.

The literature included thus far succeeds, primarily in underlining the complexity of problem solving and the interaction of this process with such skills as are related to the reading act and to intelligence.

VARIETY IN PRESENTING PROBLEMS

The literature to follow leads more to the theme of this study; that which looks at different ways of presenting learning or work material to individuals.

For some time it has been suggested that the greater variety of situations to which a child must accomodate his behavior, the more flexible his attitude becomes. To this Biggs (1969) says that "the pupil of the electronics age requires an educational environment that allows him maximum participation in discovery; . . . schools . . . must provide a multiplicity of stimuli that will spark the child's curiosity and engender a continuing desire to learn" (p. 4).

Bingham (1958) feels that allowing children variation in the "ways of working" is an important condition in building a conducive problem solving environment. In her own words:

> A program filled with many different ways of working provides opportunities for various problems to arise naturally, promotes possibilities for the teacher or an individual child to make the rest of the group aware of diverse problems, and leads the child to resourcefulness in seeking problem solutions. A cross section of ways of working is needed to challenge individual interests and powers. It is needed to stir imagination, encourage ideas, multiply recognized choices, foster creativity, provide different forms of action, and influence a disposition toward problem solving. (p. 55)

The report of a recent UNESCO conference suggests that the involvement of more senses results in more efficient learning. "If a child only hears, but does not see, he does not learn as well as if he hears and sees at the same time. If he can touch as well as hear and see, he will learn more soundly." (Biggs and MacLean, 1969, p. 4)

PROBLEM SOLVING SUCCESS AND MODES OF PRESENTATION

Interest in the comparative effects of different modes, or channels of communication was understandably lacking prior to the wide use of radio, and somewhat later, television. With the introduction of these and other electronic devices into schools however, both media and educational researchers have been prompted to test the possible advantages and disadvantages of the main communication modes; specifically, the audio, the pictorial, and the print.

Hartman (1961) reviewed much of the research which compared the above mentioned channels. For example, in

fourteen studies which used nonsense syllables and digits as the material to be learned, Hartman found eight which favored the print channel; five that reported the audio most effective and one study that indicated no difference. He also found that the results which favored the audio, were with young children while those which favored the print dealt with older children and adults.

In fifteen studies, also comparing the audio and the print modes, but with material to be learned that of meaningful words presented in serial order, Hartman (1961) located eight studies favoring the print mode; three favoring the audio and four which reported no significant difference. Here also, those studies giving advantage to the audio channel used material more suitable for young children, while those favoring the print were adult orientated. From the findings of both of these studies, Hartman made the following generalization: "Relative channel effectiveness depends upon the difficulty or complexity of the material for a given group of subjects provided the subject can read" (p. 237). It seems reasonable to assume that the limited reading skills of the younger children would be a significant factor in making the audio mode their favorite.

In studies which examined the pictorial mode in relation to the audio and print modes, Hartman reported as follows: In fourteen of these reviewed studies, five found advantages for the pictorial over the print. Six of these studies found superiority for pictorial over audio, and three

reported no consistent differences.

Hartman (1961) also gave some interesting research summaries which centered on combinations of presentation modes. Of thirteen of such studies, four supported the audio with pictorial channels over the audio alone; three studies found the audio with pictorial mode better than the pictorial alone.

Grosslight and Kale (1955) in one such study, reported advantages for a print with pictorial combination, but not for the audio-pictorial forms. Hartman (1961) also found the audio-pictorial the least satisfactory of the verbal-pictorial combinations.

A research project by Burt (1967) which also attempted to determine the comparative effectiveness of different modes of presentation, appears worthy of more detail. The modes utilized in his study were the visual-verbal (print or T_1), the visual-non-verbal (picture or T_2), and the audio-verbal (spoken word or T_3). Mode effectiveness was measured by the number of errors made in learning a list of paired associate tasks, and by retention of the learning which was measured at four different time intervals.

One hundred and twenty-eight grade eight students were randomly placed in three treatment groups and four post-test groups as illustrated in Table 1.

During the learning phase of the study, Burt presented the stimulus and response halves of the learning tasks together. The subjects were presented with the constant

Table 1

NUMBER OF STUDENTS AS ARRANGED IN TREATMENT AND POST-TEST GROUPS

	Immediate	20 Minutes	48 Hours	7 Days
Treatment 1	10	10	10	10
Treatment 2	10	10	10	10
Treatment 3	10	10	10	10

stimulus half of the paired associates in the form of a projected, printed word. The response half of the pair was simultaneously presented in the form of a printed word, as a picture, or as a spoken word, depending upon which treatment group the subject was a member of. Each subject was exposed to only one response mode.

To test each subject, the printed stimulus word was presented, and the pupil responded by selecting the printed word, picture, or by saying the correct response, again depending upon the mode by which the learning task was presented. As each pair (stimulus and response) was "learned" to a criteria of two correct responses, it was eliminated from the presentation. The researcher kept a score of each response until all pairs were learned. In addition, each subject was post-tested once, according to the post-test group to which each had been assigned.

Burt's analysis of results indicated that in the sample of grade eight students, those who were taught the printed, low in meaninfulness stimuli word, with picture response, had significantly fewer errors to criterion than those students who were presented the learning tasks with either the printed or spoken word responses. He reported no significant difference in the number of errors to learning criterion between students who had learned using visual-verbal (print) and those who had learned using the auditory-verbal (spoken) response modes. After a delayed testing of five days the student who was given the pictured response

mode scored significantly better than either the spoken or the printed word response mode groups.

Collet (1964) hypothesized that other things being equal, the efficiency of the teaching technique increased with the number of sense modalaties being used. In order to test the above hypothesis, three comparable groups of junior high students were taught equivalent tasks by three different techniques. The first teaching technique employed visual clues only, the second used both visual and auditory cues, and the third used the visual, auditory and the kinesthetic cues. The task in which Collet had his subjects perform was the learning of a set of symbols which represented certain letters of the alphabet. After correcting for possible effect due to differences among the sets of symbols used, and the different orders of presentation, each group was taught by all three techniques and in the process used all sets of symbols.

At the end of the treatment segment of his experiment, Collet administered the same test to all three groups, but assigned marks to the visual, audio-visual, or audio-visual-kinesthetic categories depending upon which technique was used for teaching the particular symbols. Thus a visual, an audio-visual, and an audio-visual-kinesthetic score was obtained for each individual. Using the analysis of variance technique on his data, Collet found some rather significant correlations from which the following statements were made:

(1) For most students, audio-visual-kinesthetic techniques were more efficient than the visual techniques

for the teaching of symbols.

(2) For most students, audio-visual-kinesthetic techniques were more efficient than the audio-visual techniques for the teaching of symbols.

(3) For most students, audio-visual techniques were more efficient than visual techniques for teaching symbol recognition, but there seems to be no difference for teaching students to draw the symbol from memory. (p. 2)

A recent graduate research project by Riva-Cambrin, and Anderson (1969) dealt with the comparative effects of two different modes of presenting arithmetic problems and the resulting findings provided some of the inspiration for this study. Fifty grade six students were divided into two groups and each group administered two problem solving tests. Although the two tests differed in presentation mode, (test A, a verbal problem solving test requiring reading, test B in cartoon form with few words) they basically tested the same things. Both groups of students were required to take the two test sections, test A and test B; one group was administered test A first, while the other, test B first. A comprehensive reading score was obtained for each pupil from the results of the Gates Reading Test which had been administered in June of 1969.

An analysis of results showed that it did not matter which test was written first, as both groups achieved significantly better results on test B, the cartoon form of the problem solving test. When the comprehensive reading scores of the students were compared with the percentage increases (test B over test A), it was found that the lower the reading scores of the pupils, the more the benefit from the cartoon

setting. (Figure 1)

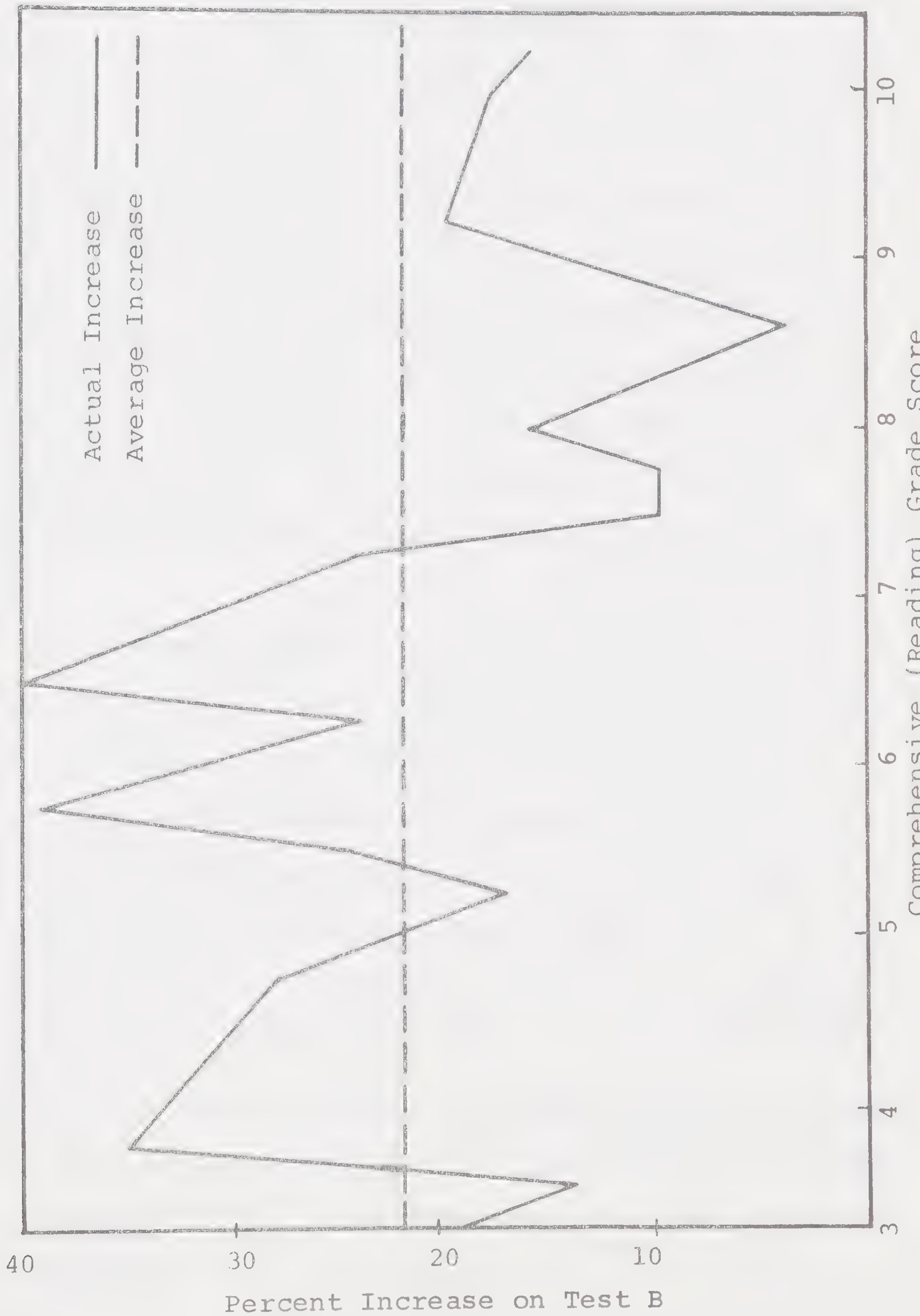
SUMMARY

In summary, research appears to give support to the contention that many factors contribute to the student success or failure in activities related to arithmetic problem solving. The complexity of the problem solving process, the interrelatedness of this process with many of the communication skills, and the general ability of the student, are examples.

There is also an increasing amount of literature and research that reports the relative effectiveness of the communication channels with regard to the presentation of classroom content. There exists a distinct need however, for research which looks at specific learners of high, average and low ability and how these learners respond to the various modes through which curricular materials are presented.

FIGURE 1

PROBLEM SOLVING TEST SCORE INCREASES AND COMPREHENSIVE READING ABILITY



Chapter 3

METHODS AND PROCEDURE

THE SAMPLE

The population and sample for this study consisted of all 234 grade six pupils enrolled in the six schools under study by the Human Resources Research Council of Alberta. That is, all grade six pupils in the IPI schools (Forest Heights Elementary, St. Vincent De Paul Elementary and Millarville School) and their respective controls (Princeton Elementary, St. Leo Elementary, and Red Deer Lake School).

The grade six students were chosen for this study for a variety of reasons. First, perhaps, the students, by this stage of development, have their own preferred styles of learning fairly well established. Secondly, at this level one may assume, with fair assurance, that a wide range of student performance and ability exists, particularly in the communication skills of reading, listening and interpreting. This assumption should also hold for the skills of arithmetic. The results of a pilot study also indicated that the content and difficulty of the problem solving test used in the four treatment modes was most compatable with this particular group of students.

TEST MATERIALS

The Problem Solving Tests

The basic problems common to all four treatment modes were designed specifically for this study by the researcher. Logically, they were designed with specific criteria in mind. Each of the ten problems were to:

(1) be novel in the sense of being both interesting and new to the students in the study,

(2) be consistent with the range of ability levels of the students in the sample, and

(3) be conducive to visual and auditory representation as well as to the usual printed form.

Multiple choice answers to the problems were not randomly chosen mistakes, but represented both computational and operational errors.

To the R-test and the VR-test provided in Appendix A and B, were added a taped verbatim of each, to enable the four presentation modes used in the study.

Necessarily, each treatment mode was constructed so as to be an equivalent form of the other three; the differences between them being in presentation mode only. In this way only could statistical differences be attributed to the effects of mode of presentation.

An internal reliability score was obtained for all the problem solving test modes in combination. Since each test was structurally identical, this was considered acceptable. The Kuder Richardson test of Internal Reliability Formula 20

was the specific instrument used and it yielded a figure of .5154.

<u>The Metropolitan Achievement Test</u>

The reading section of this test was used as a basis for determining the reading ability of each subject in the sample. All grade six pupils in the schools (IPI and CONTROL) were administered the test and grade equivalents were calculated for each of these pupils.

Basically, the reading section of <u>The Metropolitan Achievement Test</u> consists of a series of reading selections, each followed by several questions designed to measure various aspects of reading comprehension, including the following:

(1) ability to select the main thought of a passage, or to judge its general significance,

(2) ability to understand the literal meaning of a selection, or to locate information explicitly set forth,

(3) ability to see the relationships among the ideas set forth in the selection and to draw correct inferences from the selection,

(4) ability to determine the meaning of a word from context or to judge from context which of several possible meanings of a word is the appropriate one.

The selections are reportedly graduated in difficulty through control of sentence length and structure, vocabulary, and overall length. The authors also say that the questions based on each selection vary in difficulty and that there is

progression from easy to difficult as the pupil proceeds through the test. The time limit on the test (25 minutes), appeared generous so that little emphasis was placed on speed of reading as such.

Since the study was looking at the effects of mode of presentation with students of high and low ability, students were grouped into these categories on the basis of scores obtained from The Metropolitan Achievement Test. Details of the grouping procedures will be found in the statistical design section of this chapter.

The Canadian Test of Basic Skills (CTBS)

The mathematics section of this test was administered to all students in both IPI and Control schools, by the Human Resources Research Council of Alberta. Although the results obtained from this test were to serve as pre-scores for the Council's comparison of regular and individualized instruction, they were also used to determine whether students would be placed in the high or the low mathematical ability groups required in this study.

The CTBS, mathematics section, includes two parts. The first section, M-1, is designed to evaluate the students understanding of their number system, of mathematical terms, and of the operations. Broadly, the concepts tested are those in currency, decimals, equations, fractions, geometry, measurement, numerals and number systems, percentage, ratio and proportion, and whole numbers. Each of these larger headings are broken into sub-parts with questions based on

each of these sub-sections.

The M-2 section of the CTBS is a test on arithmetic problem solving ability. Scores obtained from both of these sections were used to arrive at a comprehensive arithmetic grade score for each student in the study.

THE PILOT STUDY

As mentioned, a pilot study was conducted in one Edmonton elementary school in order to better match the interest and abilities of the students with the four modes of the problem solving test. The grade six teacher, for example, was asked to select four groups of five students, each group to comprise of two high, two low, and one average ability pupil. The four groups chosen by the teacher were then randomly assigned to one of the four treatment modes.

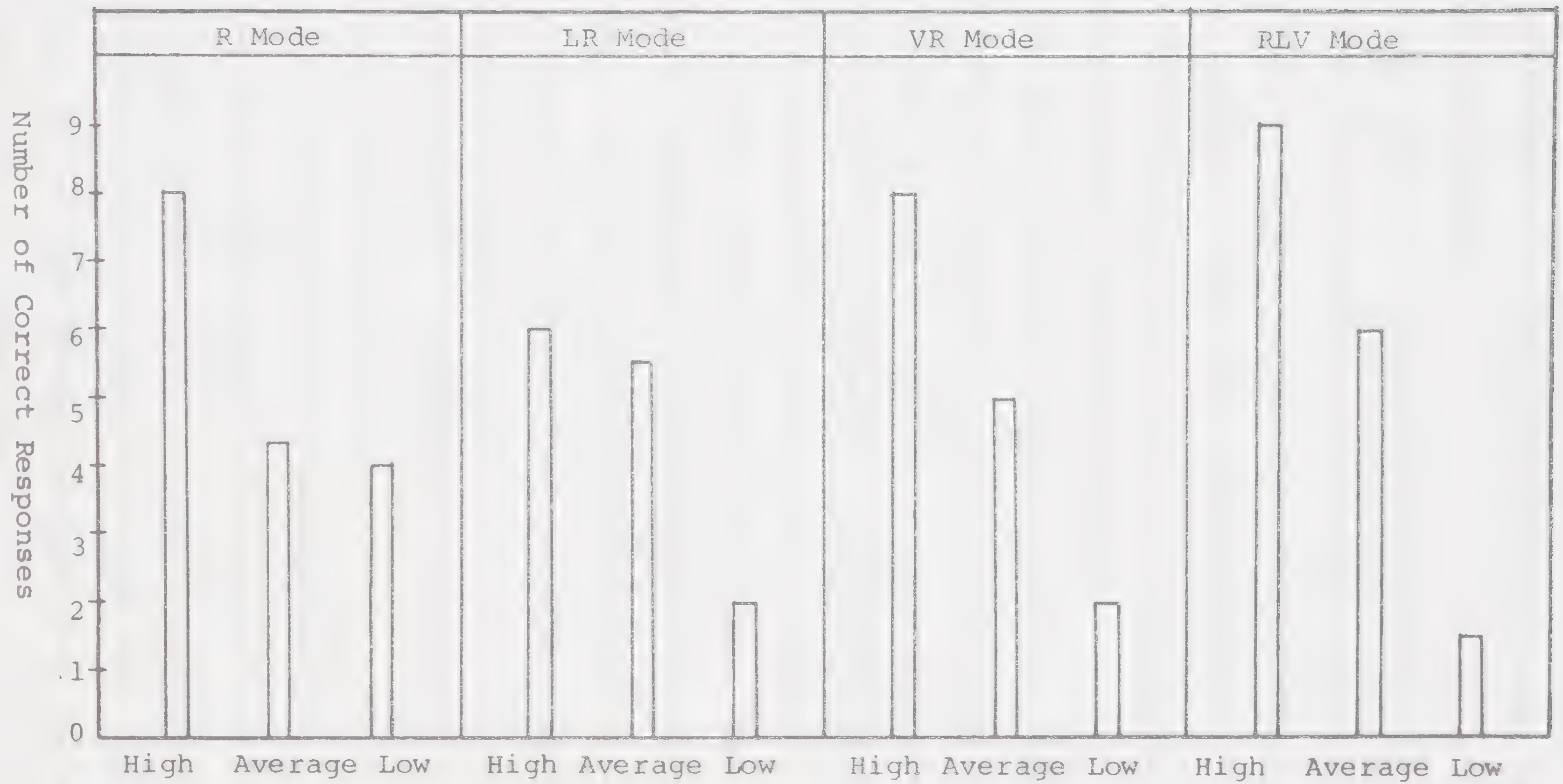
The student performances on the four problem solving modes were then compared with the teacher designated ability levels and the resulting spread of scores analyzed. As illustrated in Figure 2, the difficulty of the four problem solving test modes appeared to be consistent with the possible range of abilities of grade six students.

PROCEDURE

Pupils in each of the six schools were randomly assigned to one of the four problem solving modes. Although the number of subjects varied from school to school, the randomization was such that where possible, within each school,

FIGURE 2

HIGH, LOW, AND AVERAGE STUDENT PERFORMANCES ON THE FOUR PROBLEM SOLVING MODES



equal numbers of pupils were administered each treatment mode setting. The distribution of pupils to the four modes can be seen more clearly in Table 2.

The reason for there being fewer subjects in the VR and RLV test modes was absenteeism. At no time however, did this unequal number of students in the four modes interfere with statistical analysis of the data obtained from the students. Each design either took this fact into account, or involved an equal-cells sampling technique.

As to the actual testing situation, the four problem solving test modes were designed so that the researcher was able to work with two groups at one time. Since an individual reading achievement score was required, the regular classroom teacher willingly administered a reading test instrument to the two groups not being handled by the researcher. The reading section of the Metropolitan Achievement Test was the specific instrument used by these teachers. Because both the problem solving test and the reading test required approximately equal time to complete, exchanging groups for testing presented no real difficulty. The physical arrangement of student groups is illustrated in Figure 3.

All students in the study were assured that the results from their work would not be used as report card evaluation. This was to reduce any test anxiety which the students may have had. Students were also told that there was to be no time limit on the problem solving test, although their reading test would be a timed one.

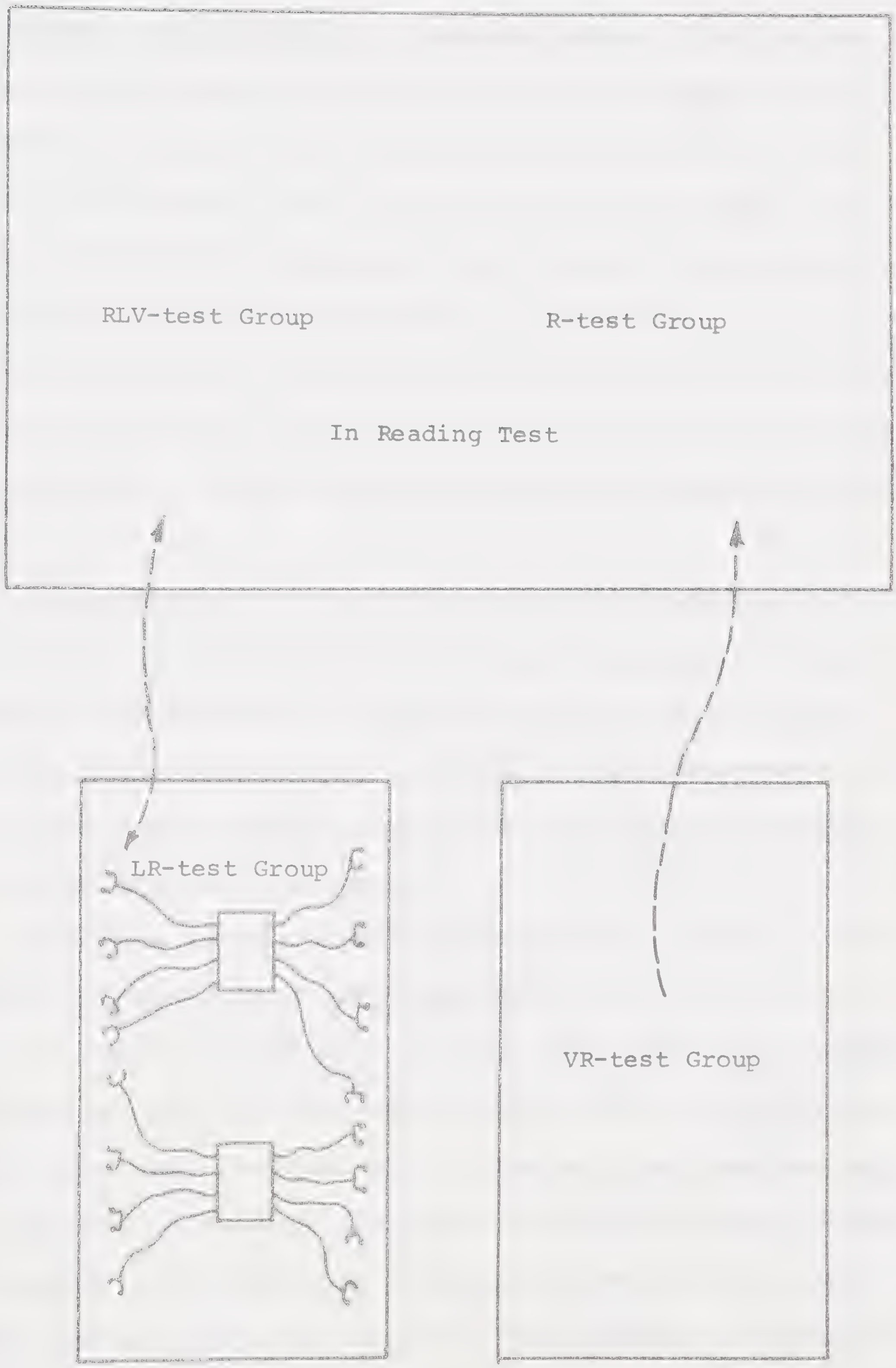
Table 2

RANDOM ASSIGNMENT OF STUDENTS FROM IPI AND CONTROL SCHOOLS TO THE FOUR PROBLEM SOLVING TEST MODES

School	Mode			
	R	LR	VR	RLV
Forest Heights	14	14	15	12
St. Vincent De Paul	12	12	10	10
Millarville	3	3	2	2
Total in IPI	29	29	27	24
Princeton	15	15	15	15
St. Leo	14	14	14	13
Red Deer Lake	5	5	5	6
Total in Control	34	34	32	34
Total	63	63	59	58

FIGURE 3

PHYSICAL TESTING ARRANGEMENT



Prior to placing any of the pupils in their respective treatment groups, a short orientation period was held with all pupils to assure their familiarity with the particular problem settings in the treatment modes. The reason for this session was that some of the pupils would be disadvantaged if they did not understand the use of the car odometer and the yard markings on the football field. In this orientation, the researcher was careful to give the same instruction to all of the schools in the study. In this same period, students were also directed in the use of test answer sheets as all of their responses were to be recorded on this device for both student convenience and the researcher's ease of marking.

The subjects in the R-test treatment mode were given an arithmetic problem solving test that necessitated the reading of each problem in order to arrive at the desired solutions. (See Appendix A). Pupils in the R-test mode worked independently while the researcher operated the tape recorder for the RLV-test group.

Subjects in the LR-test treatment were given a taped equivalent of the R-test, but they could, in addition to listening, read the problems, as did those pupils in Treatment one. That is, all ten problems and multiple choice options in the R-test were recorded on a Cassette tape recorder and played through individual listening terminals to each student in this group. Although the researcher operated the tape recorder for all subjects, they all were assured of abundant

time to complete every problem, and that they could request a playback at any time. The students in this treatment were instructed to read and listen simultaneously to the problems as they appeared in the test. They were also told not to work ahead, but rather re-read completed questions if they had extra time.

The contention in this mode was that if less skillful readers were allowed to listen to the verbal problems, in addition to reading them, they might have demonstrated superior performance.

Subjects who were randomly placed in the VR-test treatment mode were presented a visual illustration in addition to the worded problem. (See Appendix B). Students were reminded that they could use all available information in order to solve the ten problems in this test mode. The diagram which accompanied each problem was designed so as to be an aid to those students who may have preferred visual representation. This test, like the R-test, was worked independently by each student while the researcher operated the tape recorder for the LR-test group.

It follows that the subjects involved in the RLV-test group were able to listen and, or read the problems, as well as utilize visuals, in their problem solutions. This treatment was designed so as to appeal to the wide range of individual learning styles. Good readers could read the problems, poor readers listen to them, and so-called "visiles," approach them pictorially, or some may have chosen to use all modes.

Students here were also allowed ample time to complete questions and playbacks were allowed. These subjects, like those in treatment two, were told that they could work back but not ahead of the tape recorder.

In order to nullify any effect which could be caused by the order in which reading and problem solving tests were given, the order in which these tests were given was reversed from the one school to the next. That is, if the R and the RLV groups at one school were given the Metropolitan Achievement Test first, while the LR and the VR test groups were simultaneously involved with the problem solving test, the order would be reversed for the second school.

A regular audio Cassette tape recorder was used as the means of presenting the listening section of the test. This device was connected to one and sometimes two junction boxes, to which, from eight to sixteen headsets could be plugged. A headset was worn by each subject in the listening modes, and an additional one was used by the researcher. The volume and the rate at which problems were presented could in this way, be controlled for the student. Individual volume needs could also be adjusted by the student.

STATISTICAL PROCEDURES

The analysis of variance technique was chosen as the statistical means of analysing the data in this research. Hypothesis one, which was looking for significant differences among subjects who were presented different modes of the

problem solving test in their ability to solve problems, was analyzed by the one-way analysis of variance (ANOVA 10)* method.

The testing of hypothesis two was somewhat more complicated. Here we were controlling for reading ability and looking for significant interaction between modes of presentation and arithmetic ability on the criterion of problem solving ability. The first step was to dichotomize the sample into high and low arithmetic categories. This was done by utilizing the M-1 and M-2 scores from <u>The Canadian Test of Basic Skills</u>. Specifically, those who placed above a combined grade score of 6.2 were regarded as of high ability, while those who scored below 6.0 were pupils of lower ability. The scores of subjects from 6.0 to 6.2 inclusive, represented a cut-off, enabling a better high vs low dichotomy. Twenty-eight of the total sample were eliminated by using this system. The next step in testing the second hypothesis was to set up a frequency table in order to establish how many subjects were high and how many low in arithmetic ability, and which of these were in each of the four modes. Table 3 illustrates this arrangement. From this breakdown, students were randomly assigned to form the equal cells also shown in Table 3.

Two-way analysis of covariance (ANCV20), using reading as the covariate was the statistical technique used in testing this hypothesis.

Results from the testing of hypothesis three was to be found within the analysis output of hypothesis two.

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*The statistical program referred to in this study (e.g. ANOVA 10) are those maintained by the Division of Educational Research, University of Alberta, Edmonton.

Table 3

ARRANGEMENT OF HIGH AND LOW ARITHMETIC AND READING SUBJECTS IN MODE BEFORE AND AFTER RANDOMIZED EQUAL CELLS ASSIGNMENT

Arithmetic	R	LR	VR	RLV
High Ability	30	25	36	21
Low Ability	20	26	21	26
			Total Randomized Distribution	
Arithmetic	R	LR	VR	RLV
High Ability	20	20	20	20
Low Ability	20	20	20	20
			Equal Cells Assignment	
Reading	R	LR	VR	RLV
High Ability	32	28	36	27
Low Ability	28	26	24	24
			Total Randomized Distribution	
Reading	R	LR	VR	RLV
High Ability	24	24	24	24
Low Ability	24	24	24	24
			Equal Cells Assignment	

A similar process to that used in testing hypothesis two was used for hypothesis four. Here arithmetic ability was controlled for and interaction between mode of presentation and reading ability on the criterion of problem solving ability examined for level of significance. This time a dichotomy of high and low readers was established on the basis of reading grade scores obtained from The Metropolitan Achievement Test. Students who obtained a grade score above 7.0 were grouped high, while those below grade 6.7 were grouped low in reading ability. The resulting distribution is also found in Table 3. Again, subjects whose grade scores fell on and between these scores were removed so as to obtain better high-low separation. Eleven subjects were eliminated in this cut-off. Because the reading levels of the students were generally high, and because the testing date was late (May 5), the separation points are fairly high.

The third step in analyzing hypothesis four was to sample for equal cells. Two-way analysis of covariance (ANCV 20) with arithmetic as the covariate was the statistical treatment used to test this hypothesis.

The information required for checking hypothesis five was reported in the analysis of hypothesis four.

The testing procedure used on hypothesis six was similar to that of two and three. A frequency table was constructed, this time illustrating those students in the IPI and Control schools who participated in the four problem solving test modes. Since equal cells were necessary for the statistical design used, twenty students from the total in each cell were

randomly reassigned to form the equal cells illustrated in Table 4.

Since hypothesis six was looking for interaction between type of schools (IPI and Control) and mode of presentation of problems, and because reading and arithmetic achievement were to be controlled, the two-way analysis of covariance (ANCV 20) technique was again utilized. Results from the testing of hypothesis seven were to be found within the analysis output of hypothesis six.

Since hypothesis eight and nine were similar to seven, they utilized the identical two-way analysis of covariance (ANCV 20) technique for checking. However, where hypothesis seven used reading and arithmetic as covariates, hypothesis eight used reading only and hypothesis nine arithmetic only as covariates.

Table 4

ARRANGEMENT OF IPI AND CONTROL SCHOOL SUBJECTS IN MODE BEFORE AND AFTER RANDOMIZED EQUAL CELLS ASSIGNMENT

School	R	LR	VR	RLV
IPI	29	23	29	20
CONTROL	32	31	34	33

School Mode Distribution

School	R	LR	VR	RLV
IPI	20	20	20	20
CONTROL	20	20	20	20

School Mode Equal Cells

Chapter 4

THE FINDINGS OF THE STUDY

The findings of the study are presented in two sections. The first section contains the analysis of the data, with respect to the hypothesis stated in Chapter 1, and further described in Chapter 3. The second section contains a description of various relationships between student ability and modes of presentation not found in the major hypotheses of the study. A summary of results will conclude this chapter.

THE FINDINGS WITH RESPECT TO THE HYPOTHESES

Hypothesis One:

> On the Criteria of Problem Solving, there are no significant differences among the scores of groups of subjects who were presented with different modes.

The results from the analysis of this null hypothesis reveal that it could not be rejected. As indicated in Table 5, at the .05 level there were no significant differences between the four presentation mode groups on the criteria of problem solving.

The table does however, indicate an ordering of the mean scores. The lowest mean score was made by the single moded R group, while the triple moded RLV group had the highest score. Intermediate mean scores were obtained from

Table 5

ONE-WAY ANALYSIS OF VARIANCE ON DIFFERENCES BETWEEN MODES OF PRESENTATION

Group	Number in each group	Mean score	Variance	Standard Deviation
R-Mode	61	5.9836	3.6164	1.9017
LR-Mode	55	6.3091	3.9583	1.9895
VR-Mode	63	6.4762	4.8341	2.1987
RLV-Mode	53	6.8491	3.5537	1.8851

DFM 232 F - 1.83 P - 0.1419

the two double moded LR and VR groups.

Hypothesis Two:

> Controlling for reading ability there is no significant interaction between modes of presentation and arithmetic ability, relative to the criteria of problem solving.

From the two-way analysis of covariance on this arrangement, with reading ability as the covariate, this hypothesis could not be rejected. This is shown in Table 6.

Hypothesis Three:

> Controlling for reading ability there are no significant differences between high and low arithmetic ability groups on the criteria of problem solving.

The testing of this null hypothesis by analysis of covariance resulted in its being rejected. Table 6 shows the level of significance to be .001.

Table 7 illustrates the problem solving means for students of high and low arithmetic ability, separately and in the four test modes. Since reading ability was controlled for in this analysis the adjusted means are those which have taken this skill into account.

The problem solving mean scores shown in Table 7 follow a similar pattern to those given in Table 5. Again, the R mode group received the lowest mean score while the RLV mode group the highest. Although the order is reversed, the LR and VR mode groups, in like manner, achieved the intermediate mean scores.

Table 6

ANALYSIS OF COVARIANCE FOR THE VARIABLES OF ARITHMETIC ABILITY AND PRESENTATION MODE WITH READING ABILITY AS THE COVARIATE

Source	SS	DF	MS	F	P
Differences between high and low students in arithmetic	43.58	1	43.58	13.95	0.001
Difference between modes of presentation	22.70	3	7.566	2.42	0.068
Interaction between arithmetic ability and mode of presentation	18.16	3	6.055	1.94	0.126
Error	471.7	151	3.124		

Table 7

PROBLEM SOLVING MEAN SCORES FOR THE VARIABLES OF ARITHMETIC ABILITY AND PRESENTATION MODE

	Unadjusted means	Means adjusted for reading ability
High arithmetic ability	7.31	7.06
Low arithmetic ability	5.59	5.84
Mode R	5.90	6.01
Mode LR	6.45	6.34
Mode VR	6.37	6.40
Mode RLV	7.07	7.05

Hypothesis Four:

> Controlling for arithmetic ability there is no significant interaction between mode of presentation and reading ability, relative to the criteria of problem solving.

After testing this hypothesis by the analysis of covariance design (arithmetic the covariate), the null hypothesis again could not be rejected.

Table 8 indicates that there was no significant interaction between the way in which problems were presented in the four modes and the reading ability of the pupils, with arithmetic ability used as the controlling factor.

Hypothesis Five:

> Controlling for arithmetic ability there are no significant differences between the high and low reading ability groups on the criteria of problem solving

The information used to test hypothesis five, found in the analysis of hypothesis four, is illustrated in Table 8. Clearly, the null hypothesis was rejected in that on the criteria of problem solving, there were significant differences between the high and low ability reading groups, with the effect of arithmetic ability controlled. Table 9 shows the adjusted problem solving test means of the high and low readers, and of these readers in the four mode groups.

From Table 9 we find the same ordering arrangement of mode groups as those found in Tables 5 and 7. For this high and low sample of readers in the four modes, the highest problem solving score mean was again made by the RLV mode group. The R mode group demonstrated the lowest mean score performances, with the intermediate mean scores going to the

Table 8

ANALYSIS OF COVARIANCE FOR THE VARIABLES OF READING ABILITY AND PRESENTATION MODE WITH ARITHMETIC ABILITY AS THE COVARIATE

Source	SS	DF	MS	F	P
Differences between high and low readers	40.79	1	40.79	12.71	0.001
Differences between modes of presentation	22.80	3	7.60	2.37	0.072
Interaction between reading ability and mode of presentation	5.36	3	1.78	0.56	0.644
Error	587.5	183	3.210		

Table 9

PROBLEM SOLVING SCORE MEANS FOR THE VARIABLES OF READING ABILITY AND PRESENTAITON MODE

	Unadjusted means	Problem solving means adjusted for arithmetic ability
High reading ability	7.09	6.91
Low reading ability	5.74	5.92
Mode R	5.89	5.87
Mode LR	6.48	5.53
Mode VR	6.48	6.44
Mode RLV	6.81	6.82

same LR and VR modes.

Hypothesis Six:

> Controlling for reading and arithmetic ability there is no significant interaction between types of schools (IPI - control) and modes of presentation relative to the criterion of problem solving.

It followed from the analysis shown in Table 10 that the null hypothesis as stated, could not be rejected. That is, no predictability was possible between type of school and mode of presentation when the arithmetic and reading abilities of the subjects were taken into account.

For the interaction between type of school and presentation mode to be significant at the .05 level, with 3 and 150 degrees of freedom, the F ratio would have had to be greater than 2.67. As indicated, the analysis gave an F ratio of only .125.

Hypothesis Seven:

> Controlling for reading and arithmetic ability there are no significant differences between IPI and control schools on the criterion of problem solving.

Table 10 shows that to be able to reject this hypothesis and report significance at the .05 level, the analysis must have shown an F ratio of at least 3.91. However, the reported ratio was only 2.60; clearly not significant. That is, when the reading and arithmetic abilities of the students were controlled factors, those in the IPI did not do significantly better than those in the control schools on the criterion of problem solving.

Table 10

ANALYSIS OF COVARIANCE FOR THE VARIABLES OF TYPE OF SCHOOL AND MODE OF PRESENTATION WITH READING AND ARITHMETIC ABILITY AS THE COVARIATE

Source	SS	DF	MS	F	Pred. of F
Differences between IPI and control schools	7.12	1	7.12	2.60	Significance if $F > 3.91$
Differences between modes of presentation	16.58	3	5.53	2.02	Significance if $F > 2.67$
Interaction between type of school and mode of presentation	1.03	3	0.342	.125	Significance if $F > 2.67$
Within	410.07	150	2.73		
Total	434.79	157			

Hypothesis Eight:

> Controlling for reading ability, there are no significant differences between IPI and control schools on the criteria of problem solving.

The above null hypothesis, similar to hypothesis seven, also could not be rejected. As indicated in Table 11, the performances of students in both IPI and control schools, who took the four different problem solving modes were not significantly different.

Hypothesis Nine:

> Controlling for arithmetic ability, there are no significant differences between IPI and control schools on the criterion of problem solving.

The ninth and finaly hypothesis, as analyzed in Table 12 could not be rejected. Differences between IPI and control schools, under the mentioned controlling factor, and on the criterion of problem solving, were not significant at the .05 level.

ADDITIONAL RESULTS FROM THE ANALYSIS OF DATA

The Variable of Intelligence

Although verbal and nonverbal intelligence quotients were not taken into account in the major hypotheses of this study, individual scores in these areas were however, obtained, recorded and analyzed with the various sample arrangements utilized in the major hypotheses of this study.

For example, upon observing the scores, as shown in Table 13, it became apparent that there were differences in verbal and nonverbal intelligence between the subjects

Table 11

ANALYSIS OF COVARIANCE FOR THE VARIABLES OF TYPE OF SCHOOL AND MODE OF PRESENTATION WITH READING ABILITY AS THE COVARIATE

Source	SS	DF	MS	F	P
Differences between IPI and control schools	4.78	1	4.78	1.66	.200
Differences between modes of presentation	15.31	3	5.10	1.77	.155
Interaction between type of school and mode of presentation	.23	3	.07	.03	.994
Error	435.2	151	2.88		

Table 12

ANALYSIS OF COVARIANCE FOR THE VARIABLES OF TYPE OF SCHOOL AND MODE OF PRESENTATION WITH ARITHMETIC ABILITY AS AS THE COVARIATE

Source	SS	DF	MS	F	P
Differences between IPI and control schools	8.940	1	8.940	2.85	0.093
Differences between modes of presentation	1.827	3	6.091	1.99	0.125
Interaction between type of school and mode of presentation	2.132	3	.710	0.23	.878
Error	473.6	151	3.136		

Table 13

VERBAL AND NONVERBAL INTELLIGENCE AND PROBLEM SOLVING MEAN SCORES OF THE TOTAL SAMPLE IN THE FOUR PRESENTATION MODE GROUPS

Variables	R Mode	LR Mode	VR Mode	RLV Mode
Verbal intelligence	105	99	100	99
Nonverbal intelligence	105	103	101	100
Problem solving	5.9	6.4	6.3	6.8

in the four modes. The combined verbal and nonverbal intelligence quotients scores were used as controlling factors in the one-way analysis of covariance (ANCV 10) design to test the total sample differences between the four modes of the criterion problem solving test. Table 14 indicates however, that differences between the four mode groups were not significant.

However, when controlling for verbal intelligence separately, and using the equal cells sample of high and low ability arithmetic students described for the analysis of hypothesis three, some interesting results did emerge. (See Tables 6 and 7). Utilizing the two-way analysis of covariance ANCV 20) technique on the above sample, with verbal intelligence the covariate and problem solving ability the criterion measure, significant differences between modes of presentation appeared (Table 15). Table 16 shows the adjusted problem solving test means of the high and low arithmetic ability groups and of students in the four mode groups.

When controlling for the nonverbal aspect of intelligence on the criterion of problem solving, a similar result to that reported for the verbal 10 control was found. Again the two-way analysis of covariance (ANCV 20) was utilized with the same high and low arithmetic ability groups, and as shown in Table 17, an acceptable level of significance was indicated. Table 16 also shows the adjusted problem solving test means of the high and low arithmetic ability groups and of the students in the four mode groups. The

Table 14

ANALYSIS OF COVARIANCE FOR THE VARIABLE OF PRESENTATION MODE WITH VERBAL AND NONVERBAL INTELLIGENCE AS THE COVARIATES

Source	DF	MS	Adj. F	P
Differences between modes of presentation	3	8.868	2.352	0.073
Within group variance	226	3.770		

Table 15

ANALYSIS OF COVARIANCE FOR THE VARIABLES OF ARITHMETIC ABILITY AND PRESENTATION MODE WITH VERBAL INTELLEGENCE AS THE COVARIATE

Source	SS	DF	MS	F	P
Differences between high and low students in arithmetic	103.97	1	103.97	31.41	.001
Differences between modes of presentation	28.36	3	9.45	2.86	.039
Interaction between arithmetic ability and mode of presentation	21.94	3	7.31	2.21	.089
Error	499.8	151	3.31		

Table 16

PROBLEM SOLVING MEAN SCORES FOR THE VARIABLES OF ARITHMETIC ABILITY AND PRESENTATION MODE

	Unadjusted means	Means adjusted for nonverbal IQ	Means adjusted for verbal IQ
High arithmetic ability	7.31	7.21	7.29
Low arithmetic ability	5.59	5.69	5.60
Mode R	5.90	5.86	5.89
Mode LR	6.45	6.45	6.45
Mode VR	6.37	6.37	6.37
Mode RLV	7.07	7.12	7.08

Table 17

ANALYSIS OF COVARIANCE FOR THE VARIABLES OF ARITHMETIC ABILITY AND PRESENTATION MODE WITH NONVERBAL INTELLIGENCE AS THE COVARIATE

Source	SS	DF	MS	F	P
Differences between high and low students in arithmetic	79.03	1	79.03	24.32	.001
Differences between modes of presentation	31.65	3	10.55	3.25	.024
Interaction between arithmetic ability and mode of presentation	21.94	3	7.31	2.25	.085
Error	490.7	151	3.25		

particular instruments used for measuring intelligence quotients were the Lorge-Thorndike tests.

Comparisons Between Total and Restricted Sample

Upon seeing that there were significant differences among the different presentation mode groups when dealing with the restricted sample of arithmetic ability subjects and controlling for intelligence, it was decided to consider, more closely, the differences between restricted and total sample. Table 18 gives the results of an analysis of variance on the problem solving criteria. This information came as part of the two-way analysis of covariance (ANCV 20) design used to test hypotheses two and three.

Table 19 shows the mean problem solving scores for the subjects in each of the eight cells based on presentation mode and arithmetic ability. Since there was a significant difference in the presentation mode variable it can be assumed that this difference stemmed, at least in part, from the difference between the low achievers in the R and RLV mode respectively.

Table 20 indicates the mean scores for the total group based on the grouping according to presentation mode. According to the testing of hypothesis one, these mean scores were not significantly different. In comparing the differences among the presentation mode groups of the total sample, with the differences among the same presentation mode groups of the low arithmetic ability, it is evident that the total sample does not indicate as large a difference between the

Table 18

ANALYSIS OF VARIANCE ON THE CRITERION OF PROBLEM SOLVING WITHIN THE CELLS OF ARITHMETIC ABILITY AND PRESENTATION MODE

Source	SS	DF	MS	F	P
Differences between high and low students in arithmetic	119.02	1	119.02	36.17	.001
Differences between modes of presentation	27.95	3	9.32	2.83	.040
Interaction between arithmetic ability and modes of presentation	22.42	3	7.47	2.27	.083
Error	500.20	152	3.29		

Table 19

PROBLEM SOLVING MEAN SCORES FOR THE ARITHMETIC ABILITY GROUPS IN THE FOUR PRESENTATION MODES

	Number of subjects	R Mode	LR Mode	VR Mode	RLV Mode
High arithmetic ability	80	6.70	7.65	7.55	7.35
Low arithmetic ability	80	5.10	5.25	5.20	6.80

Table 20

PROBLEM SOLVING MEAN SCORES FOR THE TOTAL SAMPLE

	Number of students	R Mode	LR Mode	VR Mode	RLV Mode
Total sample	230	5.98	6.31	6.47	6.85

R and the RLV modes.

SUMMARY OF THE RESULTS

The results of the data analysis may be summarized as follows:

For the major research hypothesis

(1) There were no significant differences among subjects who were presented with the different modes of the problem solving test, in their ability to solve problems.

(2) On the criteria of problem solving ability, when adjustments were made for differences in arithmetic and reading ability, either separately or together, there was no significant interaction between modes of presentation and

(a) arithmetic ability,

(b) reading ability

(c) types of schools (IPI or Control)

(3) On the criteria of problem solving, there were significant differences between

(a) high and low students in arithmetic

(b) high and low students in reading

(4) There were no significant differences between IPI and Control school students on the problem solving criteria.

Further analysis revealed that:

(1) when controlling for verbal and nonverbal intelligence for the total sample on the criteria of problem solving, no significant differences between the four presentation modes were indicated.

(2) when controlling for verbal and nonverbal intelligence for the restricted sample of high and low arithmetic ability students, there were significant differences between modes of presentation.

Chapter 5

SUMMARY, CONCLUSIONS, IMPLICATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

SUMMARY

The purpose of this research was to investigate the relationship of mode of presentation to student performance in arithmetic problem solving.

Two hundred and thirty-four grade six pupils participated in the study. Every student in the population was randomly assigned to one of four treatment groups, each of which consisted of one of the presentation modes described in chapter one. The treatment for each of the four groups differed with respect to the way in which ten questions in a problem solving test were presented. For example, the R-mode group were given print only (Appendix A), the LR-mode section, a taped verbatim accompaniment of the R-mode test, plus the same R-test mode; the VR-mode group were presented with a combined visual-printed version of the questions, and the RLV-mode group were administered a three sense mode approach to the problem solving test. The problem solving tests were considered equivalent except for this presentation factor.

The actual administration of testing was done by the researcher and one classroom teacher in each school. The researcher was able to handle two of the problem solving test

modes in one sitting; one that involved the tape recorder (RLV or LR) and one of the other two which did not (R or VR). While these two tests were in progress the regular teacher administered The Metropolitan Achievement Test to the other two test groups. Upon completion of the first sitting, the groups were exchanged. Thus at the end of two 25-minute sittings a problem solving and a reading ability score was obtained for each subject in the study. Arithmetic ability scores for every pupil were supplied by the Human Resources Research Council of Alberta. These scores were obtained from the mathematics section of The Canadian Test of Basic Skills which had been administered by the Council in early September, 1969.

On the basis of all data obtained, the comparative effectiveness of reading, listening and visual presentation modes were analyzed separately and with respect to high and low ability students in reading and arithmetic. Interactions between mode of presentation and reading and/or arithmetic ability were also tested.

CONCLUSIONS

Conclusions With Respect to Major Hypotheses

Hypothesis one: According to the results of testing hypothesis one, there would be no advantages in considering specific modes of presentation of verbal arithmetic problems at the grade six level. In this study, for the total sample of students tested, none of the R, LR, VR or RLV mode groups

had any significant advantage over the other. Considerations of the arithmetic and reading ability of the pupils were not factors in this hypothesis.

Hypotheses two and three: Perhaps not surprising is the evidence that high ability arithmetic students demonstrated problem solving ability which was superior to that of the low ability group. There was also no significant interaction between presentation mode and arithmetic ability because for all modes, the high ability group attained higher problem solving scores than did the low ability group. It can be concluded that no one mode was more advantageous than any other mode for any particular ability group.

Hypotheses four and five: High reading ability students in the study were able to achieve significantly higher problem solving mean scores than their low ability counterparts. There was also no significant interaction between presentation mode and reading ability because for all modes, the high ability group attained higher problem solving scores than did the low ability groups. It can be concluded that no one mode was more advantageous than any other mode for any particular ability group.

Hypotheses six, seven, eight and nine: On the basis of results from these study hypotheses, student membership in school type, (IPI or Control) was not a significant factor. Under the controlling effects of reading and arithmetic ability we still could not expect students in the IPI schools

to do significantly better in arithmetic problem solving than those in the control schools, and vice-versa.

Finally, there was also no significant interaction between types of schools (IPI and Control) and modes of presentation because, for all modes, the IPI school students attained higher problem solving scores, although not significantly so, than did the Control school students. It can be concluded that no one mode was more advantageous than any other mode for membership in particular schools.

Conclusions with Respect to Additional Analysis

The conclusion based on hypothesis one was that on the criterion of problem solving, grade six students in general should not be expected to perform significantly better in any one of the four presentation modes. However, if the high and low arithmetic sample of students are considered, and if the variable of intelligence is controlled for, it may be concluded that students in the reading, listening, and visual (RLV) presentation mode may be expected to achieve significantly better than those in the reading (R) mode group.

IMPLICATIONS

The conclusion that any one mode is as successful as another when it comes to presenting arithmetic problem solving, still must hold. However, since children react best to a variety of materials, it can be implied that R, LR, VR, and RLV materials can be used with equal efficiency and at the

same time provide curriculum variety. Research findings (Riedesel, 1969) indicate that pupils react well to a variety of problem settings. He reports that although a best technique has not been found for problem solving, the following have been found to increase problem solving ability:

(1) Make use of drawings and diagrams as a technique to help pupils solve problems. This technique is helpful to pupils of all ability levels.

(2) Make use of orally presented problems. This approach forces the pupil to "size-up" the situation quickly. It is also representative of many out-of-school problem solving situations.

(3) Tape recordings of the textbook problems can be used with pupils who have difficulty reading them. (p. 55)

A point with regard to the total sample used in hypothesis one may be worth mentioning. Since we were dealing with the whole range of pupils, one may perhaps consider the total group as that of average ability. In this regard, there are perhaps legitimate occasions within the classroom, school, or system when curriculum decisions are made on the basis of the average. Perhaps the greatest bulk of library or resource materials would fall under this category. Most individual subject textbooks, for example, are also designed with the total realm of ability levels in mind. If it is this average or mid-ability grouping that we project our efforts toward, we can perhaps be safe in saying that no one presentation mode, reading, visual or auditory,

or mode combination need be considered with superiority over another.

If our instructional techniques are geared to the average pupil in large group situations, and there are perhaps times when this is both necessary and desirable, then variations in presentation mode need not be of any real concern.

Conventionally, teachers employ the printed mode because it is the most convenient; not because it is the most beneficial for the student and his involvement with curriculum.

The observation that high arithmetic ability pupils do significantly better than low ability pupils in problem solving, under the controlling effects of reading ability, is not overly surprising. Since success in arithmetic problem solving depends on a child's understanding of certain basic arithmetic concepts, such as number, numeration, and computation, therefore it is necessary for us to help children, especially the low ability group, to understand these concepts in order to solve story problems more efficiently.

If it can be concluded that high reading ability students will do significantly better than low reading ability students in verbal arithmetic activities, then there are various implications for both educational curriculum and instruction. Since success in arithmetic problem solving depends, in part, upon a child's reading ability, therefore it is necessary for us to help children, especially the low reading ability groups, to improve their reading skills in

order to solve problems more efficiently.

Taschow (1969) says that "the mathematics instructor needs to be aware of the special reading problems that are involved in translating math symbols into verbal statements" (p. 62). He also holds that technical vocabularies and their special concepts, the use of specialized meanings for general words, and the varied mathematical symbols should not be left to incidental learning. He suggests that a small amount of direct and planned teaching of terms and concepts can produce dramatic results both in the comprehension of these terms and in superior achievement in subject matter.

On the other hand, perhaps reading ability should not be such an important factor in determining success in arithmetic. Even the four presentation modes of this study had a common reading print channel.

Obviously, this study did not look at the realm of instructional practice in the IPI and Control schools currently being field tested with respect to individualized instruction. The fact that there were no significant differences between IPI and Control schools with respect to problem solving criteria, nor with respect to membership--mode of instruction was not to diminish the credibility of one system over another. Perhaps the IPI system of instruction has not had sufficient time to register any differences. Perhaps students have adapted to the new instructional design, and if that were so, we could not expect difference. Perhaps an enthusiasm of an individualized approach overcomes

unforeseen weaknesses.

Implications With Respect to Additional Analysis

Analysis of hypothesis one suggested that if considering overall groups of stuents, specifically grade six students in general, considerations of mode of instruction are not important. Curriculum materials and instructional techniques for the average population need not consider individual preference or need with respect to small group ability levels.

It appears, however, that if we are to consider individual learners or learner groups, specifically the high and low arithmetic ability groups, then consideration of mode should be made.

SUGGESTIONS FOR FURTHER RESEARCH

This study was conducted with grade six pupils. Would the results have been different for other levels of students? For example, Hoke (1970), who studied parental opinions of the IPI program, found that every parent who had a level one student working in the IPI program questioned the value of the instructional method for these students. Many felt that the difficulty of the materials was beyond the ability levels of these young children. A study with these students may prove interesting.

Low ability arithmetic students in this study seemed to gain more than high ability arithmetic students on the RLV mode over the R mode of the problem solving test. Perhaps

a larger sample of students with better high-low separation could give further support to this. More items in the treatment tests should also be a consideration in any such alternate designs.

Perhaps a pre-post experimental design could be tried with groups of students who would study an arithmetic topic through a particular instructional mode. Necessarily, pre- and post-test instruments would also have to be mode-orientated.

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APPENDIX A

THE VR PRESENTATION MODE

(Do not write on this test.)

1. On their trip across Canada, the Willis family stopped at Riviere Du Loup. At that point their car's odometer read |0|0|7|3|8|0|. Two hours before reaching Riviere Du Loup they had eaten lunch at a town called Edmundston. If Mr. Willis averaged 60 miles per hour what should have been their odometer reading at Edmundson?

(a) |0|0|7|3|2|0|

(b) |0|0|7|2|6|0|

(c) |0|0|7|5|0|0|

(d) |0|0|7|4|4|0|

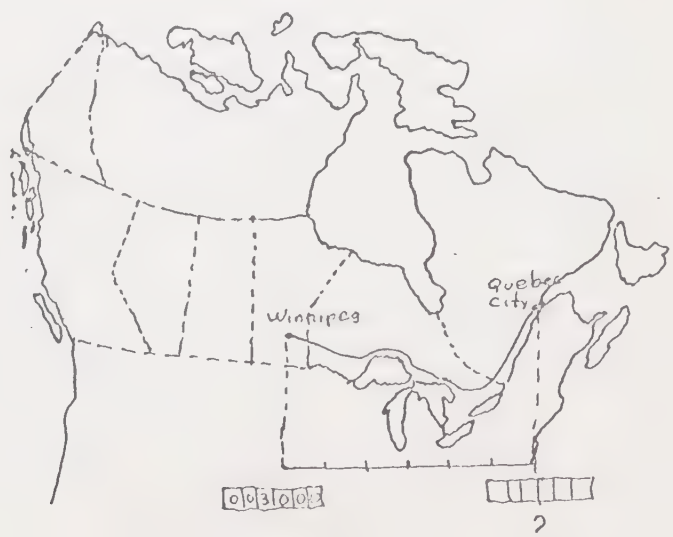
2. On their trip west Fraser noticed that at Winnipeg, Manitoba, their car's odometer recorder three thousand miles. This was six times as many miles as was on their car odometer at Quebec City Quebec, some three days before. Which of the odometer readings below would have been the correct reading at Quebec City.

(a) |0|1|8|0|0|0|

(b) |0|0|1|8|0|0|

(c) |0|0|0|6|0|0|

(d) |0|0|0|5|0|0|



3. Billy wanted to check how accurate the mileage sign was that told them how many miles they still had to travel to reach Mercoville. To do this he recorded the odometer reading at 37,851 miles. If the odometer showed 38,106 miles when they entered Merocville, how many miles back should the sign have been?

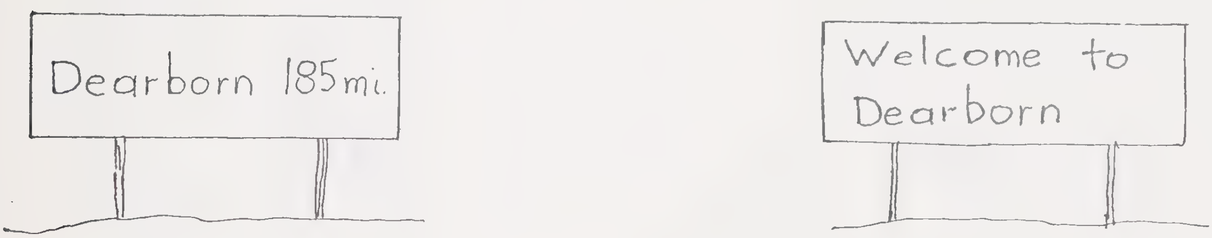
(a) 957 miles

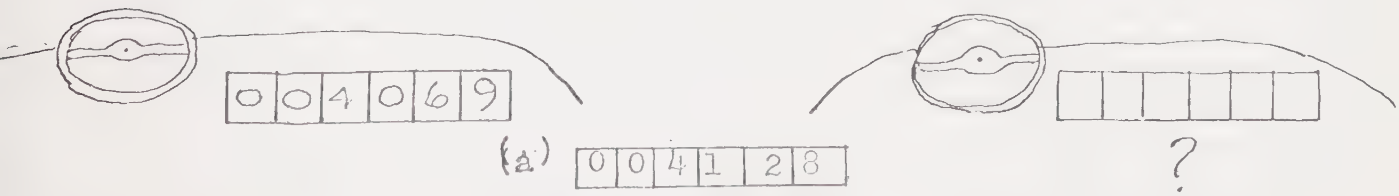
(b) 245 miles

(c) 255 miles

(d) 345 miles

4. The Jackson's family car, travelling down the highway, passes a sign which reads Dearborn 185 miles. If when they pass the sign their odometer reads 4069 miles, what numerals will appear on the odometer when they reach Dearborn?





(a) 0 0 4 1 2 8

(b) 0 0 3 8 8 4

(c) 0 0 4 2 5 4

(d) 0 3 8 8 4 0

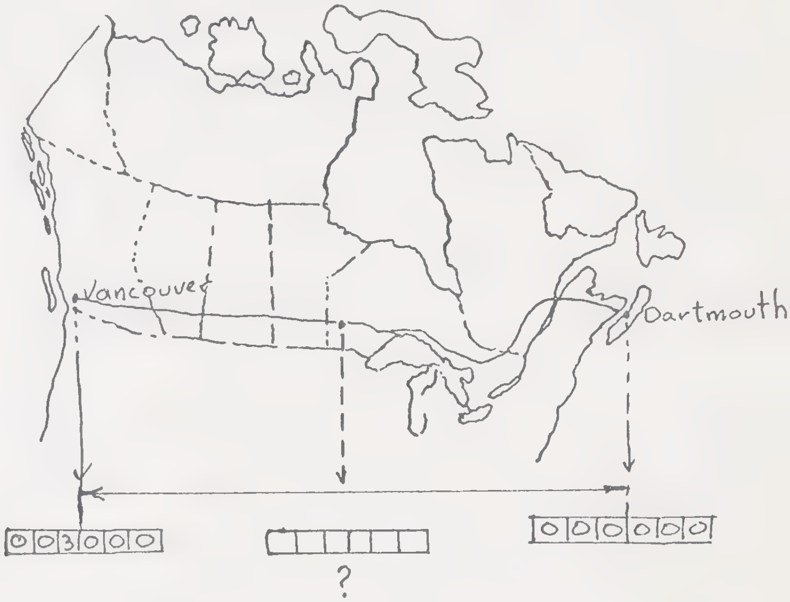
5. Mr Jackson told Billy, his son, that their new car, which has no miles on it , will have travelled about three thousand miles when they reach Vancouver, British Columbia, from Dartmouth, Nova Scotia. When the Jacksons reached Kenora, Ontario, Mr. Jackson said that they were one-half of the way home. Which of the odometer readings below would be like theirs at Kenora?

(a) | 0 | 0 | 1 | 5 | 0 | 0 |

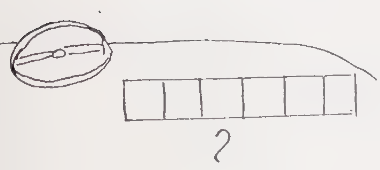
(b) | 0 | 0 | 3 | 0 | 0 | 0 |

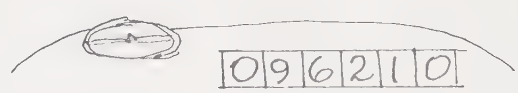
(c) | 0 | 0 | 0 | 1 | 0 | 0 |

(d) | 0 | 0 | 1 | 6 | 0 | 0 |



6. Lawrence Boner decided to attend a hockey game in Cartier Quebec. A sign beside the road read, Cartier 300 milis. If when he arrived at Cartier his odometer read | 0 | 9 | 6 | 2 | 1 | 0 | what would his odometer have read when he passed the distance sign?





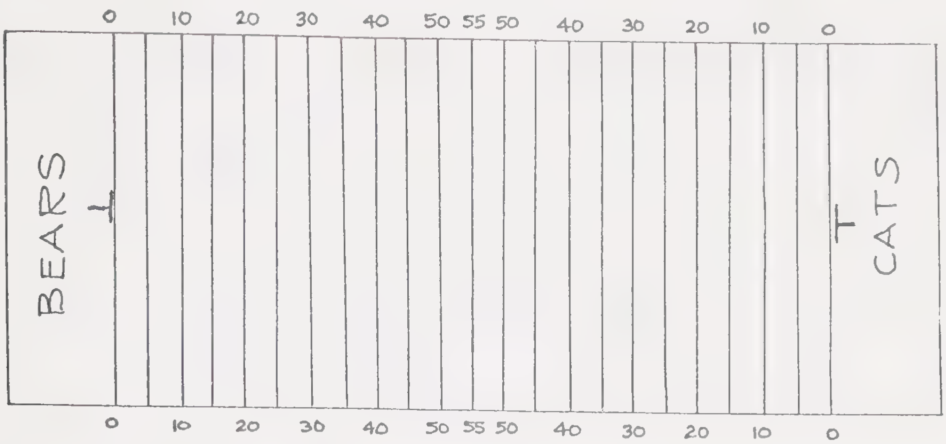
(a) | 0 | 9 | 5 | 9 | 1 | 0 |

(b) | 0 | 9 | 6 | 9 | 1 | 0 |

(c) | 0 | 9 | 5 | 8 | 1 | 0 |

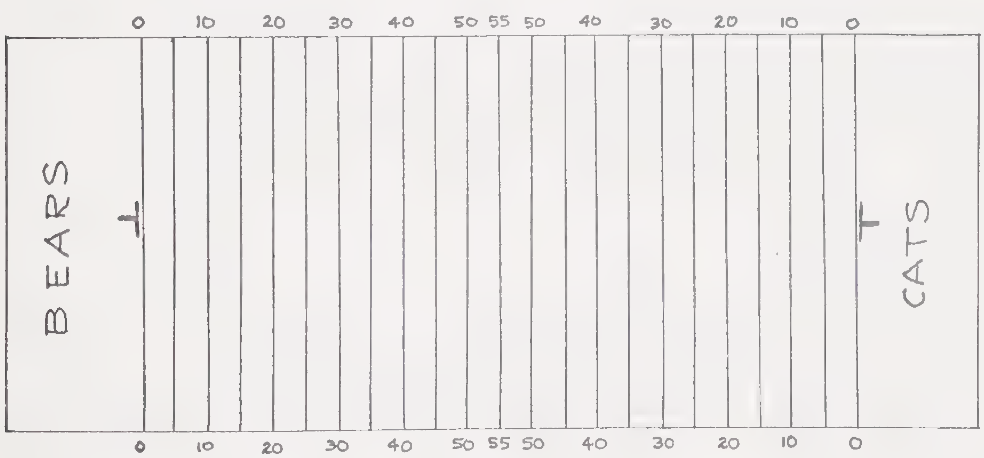
(d) | 0 | 9 | 6 | 5 | 1 | 0 |

9. At half time the ball is placed on the Cats 45 yard line. The kicker blasts the ball 65 yards where the Bears receive it. If Cox, the Bears receiver, runs the ball back 15 yards, where will the referees place the ball for the Bears first play from scrimmage?



(a) 20 yd. line
(b) 15 yd. line
(c) goal line
(d) 30 yd. line

10. If the Bears began a play from their own 10 yard line, how many times farther do they have to go in order to score a touchdown on the Cats? (Hint: field 110 yards long.)



(a) 100 times
(b) 10 times
(c) 11 times
(d) 9 times

APPENDIX B

THE R PRESENTATION MODE

(Do not write on this test.)

1. On their trip across Canada, the Willis family stopped at Riviere Du Loup. At that point their car's odometer read | 0 | 0 | 7 | 3 | 8 | 0 |. Two hours before reaching Riviere Du Loup they had eaten lunch at a town called Edmunston. If Mr. Willis averaged 60 miles per-hour, what should have been their odometer reading at Edmunston?

   (a) | 0 | 0 | 7 | 3 | 2 | 0 |

   (b) | 0 | 0 | 7 | 2 | 6 | 0 |

   (c) | 0 | 0 | 7 | 5 | 0 | 0 |

   (d) | 0 | 0 | 7 | 4 | 4 | 0 |

2. On their trip West Fraser noticed that at Winnipeg, Manitoba, their car's odometer recorded three thousand miles. This was six times as many miles as was on their car odometer at Quebec City, Quebec some three days before. Which of the odometers below was the correct reading at Quebec City?

   (a) | 0 | 1 | 8 | 0 | 0 | 0 |

   (b) | 0 | 0 | 1 | 8 | 0 | 0 |

   (c) | 0 | 0 | 0 | 6 | 0 | 0 |

   (d) | 0 | 0 | 0 | 5 | 0 | 0 |

3. Billy wanted to check how accurate the milage sign was that told them how many miles they still had to travel to reach Mercoville. To do this he recorded the odometer reading at 37,851 miles. If the odometer showed 38,106 when they entered Mercoville how many miles back should the sign have been?

   (a) 957 miles

   (b) 245 miles

   (c) 255 miles

   (d) 345 miles

4. The Jackson's family car, travelling down the highway, passes a sign which reads Dearborn 185 miles. If when they pass the sign, their odometer reads 4069 miles, what numerals will appear on the odometer when they reach Dearborn?

   (a) | 0 | 0 | 4 | 1 | 2 | 8 |

   (b) | 0 | 0 | 3 | 8 | 8 | 4 |

   (c) | 0 | 0 | 4 | 2 | 5 | 4 |

   (d) | 0 | 3 | 8 | 8 | 4 | 0 |

5. Mr. Jackson told Billy, his son, that their new car, which has no miles on it, will have travelled about three thousand miles when they reach Vancouver, British Columbia, from Dartmouth, Nova Scotia. When the Jacksons reached Kenora, Ontario, Mr. Jackson said that they were one-half ($\frac{1}{2}$) of the way home. Which of the odometer readings below would be like theirs at Kenora?

(a) | 0 | 0 | 1 | 5 | 0 | 0 |

(b) | 0 | 0 | 3 | 0 | 0 | 0 |

(c) | 0 | 0 | 0 | 1 | 0 | 0 |

(d) | 0 | 0 | 1 | 6 | 0 | 0 |

6. Lawrence Boner decided to attend a hockey game in Cartier, Quebec. A sign beside the road told him that Cartier was three hundred miles away. If when he arrived at Cartier his odometer read | 0 | 9 | 6 | 2 | 1 | 0 | what would his odometer have read when he passed the distance sign?

(a) | 0 | 9 | 5 | 9 | 1 | 0 |

(b) | 0 | 9 | 6 | 9 | 1 | 0 |

(c) | 0 | 9 | 5 | 8 | 1 | 0 |

(d) | 0 | 9 | 6 | 5 | 1 | 0 |

7. During a football game between the Bears and the Cats, the Bears scored a thouchdown on a pass and run play. Here is how it went. The play started on the Bears 40 yard line. Johnson, the Bear's Quarterback passed for 35 yards and Boners, their offensive end, ran the rest of the way for the T.D. If the field length is 110 yards, how far did Boners have to run to score?

(a) 75 yards

(b) 35 yards

(c) 5 yards

(d) 70 yards

8. It was now the Cats turn at Offence. Their play series began at their own 29 yard line. On a running play Reimer, the Cats full-back ran the ball to the Bears 35 yard line. How far did he run? (Remember the full length is 110 yards.)

(a) 64 yards

(b) 39 yards

(c) 56 yards

(d) 46 yards

9. At half time the ball is placed on the Cats 45 yard line. The kicker blasts the ball 65 yards where the Bears receive it. If Cox, the Bears receiver, runs the ball back 15 yards, where will the referees place the ball for the Bears first play from scrimmage?

(a) 20 yd. line
(b) 15 yd. line
(c) goal line
(d) 30 yd. line

10. If the Bears began a play from their own 10 yard line, how many times farther do they have to go in order to score a touchdown on the Cats? (Hint: field 110 yards long.)

(a) 100 times
(b) 10 times
(c) 11 times
(d) 9 times